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Consequences of pesticide use on spider communities in mango orchards

Donna RAYNER, Michael COATES & Robert NEWBY
Department of Biology, Central Queensland University,
Rockhampton, Queensland 4702, Australia.

Consequences of pesticide use on spider communities in mango orchards. - A preliminary study was performed during spring/summer 1993 to determine the effects of pesticide use on spider communities in Central Queensland mango orchards. The results suggest that the frequent use of pesticides reduced abundance, species richness and species diversity of spiders in these orchards, while infrequent application of pesticides did not appear to result in a change in these properties. However, when relative species abundances in orchards which have had frequent, infrequent and no pesticide applications (n = 3, n = 6 & n = 3, respectively), over three sampling periods, were compared by non-parametric multivariate analysis, changes in community structure were indicated. Web-building and hunting spiders were both found to be vulnerable to pesticides.

Key-words: Pesticides - spider abundance - species richness - species diversity - relative species abundance.

INTRODUCTION

In many field crops and orchards, pesticides are extensively used to control pests and diseases. One of the main concerns for growers is the increasing cost of pesticides and the risk of insects becoming resistant to the pesticides used. Thus, interest in the use of natural predators in agroecosystems is increasing. In recent years emphasis has been placed on the action of spiders as biocontrollers within these systems. Spiders are ubiquitous and totally predacious making them an obvious possibility as biocontrol agents. RIECHERT & LOCKLEY (1984) suggest that it is the spider community as a whole which is the stabilising influence on pest species in agroecosystems. The maintenance of community diversity as well as abundance of spiders is required to maximise the probability of a range of pest species being predated (RIECHERT & LOCKLEY 1984).

Agroecosystems tend to have unstable communities due to the use of pesticides, tilling of the soil and removal of the crop during harvesting. All of these facts may

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disrupt the community structure of spiders. Orchards are established agroecosystems where the trees are maintained for several years. Therefore, structural disruption is less than in other types of agroecosystems making them an appropriate situation in which to study the disruptive influences of pesticides on spider communities.

Mangoes are a commonly grown fruit in Central Queensland. The annual production of fruit is valued at approximately 2 x 10^6 Australian dollars per year. Many orchardists use pesticides to control pest species which are prevalent in the area. This study is a preliminary assessment of the effects of pesticides on abundance, species richness, species diversity and community structure of spiders within mango orchards.

MATERIAL AND METHODS

The mango orchards used in these studies were relatively small, ranging in size from 30 to 200 trees. They were all established orchards, with fruit bearing trees at least three years of age, and were all located in coastal areas in Central Queensland. Twelve orchards were chosen and separated into three types according to the amount of pesticide used during the three month sampling period. Unsprayed orchards received no pesticides (copper oxychloride and mancozeb). The infrequently sprayed orchards received heavy applications of fungicides but minimal insecticides (methidithion, endosulphan and dimethoate), and the frequently sprayed orchards received heavy applications of both fungicides and insecticides.

Spiders were collected over a 30 minute period from the foliage of 2 trees in each orchard during spring/summer (October, November and December), 1993. The data from the two trees were combined to give a single one hour sample per orchard for each of the three sampling times. Wherever possible the spiders were identified to species or genus level. Individuals which were unable to be identified (mainly immature) were allocated an identification number.

Species were classified as belonging to one of two guilds. Those individuals which required the use of a web for capturing prey were placed in the web-building guild. This included the clepto-parasite *Argyrodes antipodianus* which occupied the webs of larger web-building spiders and foraged for small prey trapped in the web. The hunting guild included those spiders which search for prey and did not require a web to capture prey.

The abundance and species richness of spiders were determined for each orchard at each sampling time. Species diversity within each orchard was assessed by the Shannon-Wiener Diversity Index (Krebs 1972).

The effects of pesticides on the relative abundance of spider species, or community structure, was assessed through the use of a non-parametric multivariate analysis. The ANOSIM program (Clarke 1993) was used to test the null hypothesis that there was no difference in the relative abundance of species between the frequently, infrequently and un-sprayed orchards. This test compared the abundance of each of the spider species present in each orchard at each sampling time. The Bray-Curtis index was used to produce a matrix consisting of the similarities between each pair of orchards. The average difference between the similarities within and between groups (eg. frequently sprayed compared to unsprayed) were then determined to give a true R value. The labels of the orchards were then randomly permutated (1000 times in this case) and a test R value was calculated for each permutation. If the proportion of test R values greater than the true R was less than 0.05 the null hypothesis was rejected.

RESULTS

A comparative list of the spider species and the total number of individuals of each species found in unsprayed and frequently sprayed orchards are shown in Table 1. Mean spider abundance, species richness and Shannon-Wiener Diversity Indices for each sampling period in each type of orchard are shown in Figures 1, 2 & 3, respectively. The mean values for each parameter were less for frequently sprayed compared to unsprayed and infrequently sprayed orchards. Infrequently sprayed and unsprayed orchards appeared similar.

The structure of the communities in frequently, infrequently and un-sprayed orchards was examined with a one-way ANOSIM test (CLARKE 1993), treating the samples from October, November and December as independent relicates. The infrequently sprayed orchards were found to be significantly different from infrequently sprayed and unsprayed orchards (P = 0.002 in both cases). The community structure of unsprayed and infrequently sprayed orchards were also found to be significantly different (P = 0.017). Only *Badumna* sp. and *Scytodes fusca* had an increase in the abundance of more than two individuals. *Badumna* sp. increased by one or two from 19 to 66 individuals after pesticides were used. *Poltys* sp. and *Nephila* sp. increased by one or two in the individuals in unsprayed compared to frequently sprayed orchards. *Psuedohostus squamous* had 1 individual in each of the unsprayed and frequently sprayed orchards. The remaining 39 species of the 43 species decreased in abundance (Table 1).

The total abundances of web-building and hunting spiders for each type of orchard in each sampling period are shown in Figure 4. Web-building spiders were more abundant than hunting spiders in all three types of orchard. The number of both web-building and hunting spiders appeared to be reduced by the use of pesticides.

DISCUSSION

These preliminary results suggest that spiders are greatly affected by the frequent use of pesticides in mango orchards. Not only was the abundance of spiders reduced but, species richness and diversity were also reduced. The decrease in the number of spider species and their abundance reduces the effectiveness of these predators in controlling pest species. RIECHERT & LOCKLEY (1984) suggested that no one species, no matter how abundant, is capable of holding pests in check. Therefore, community diversity must be maintained to maximise the number of different predators that will encounter a range of pest species.

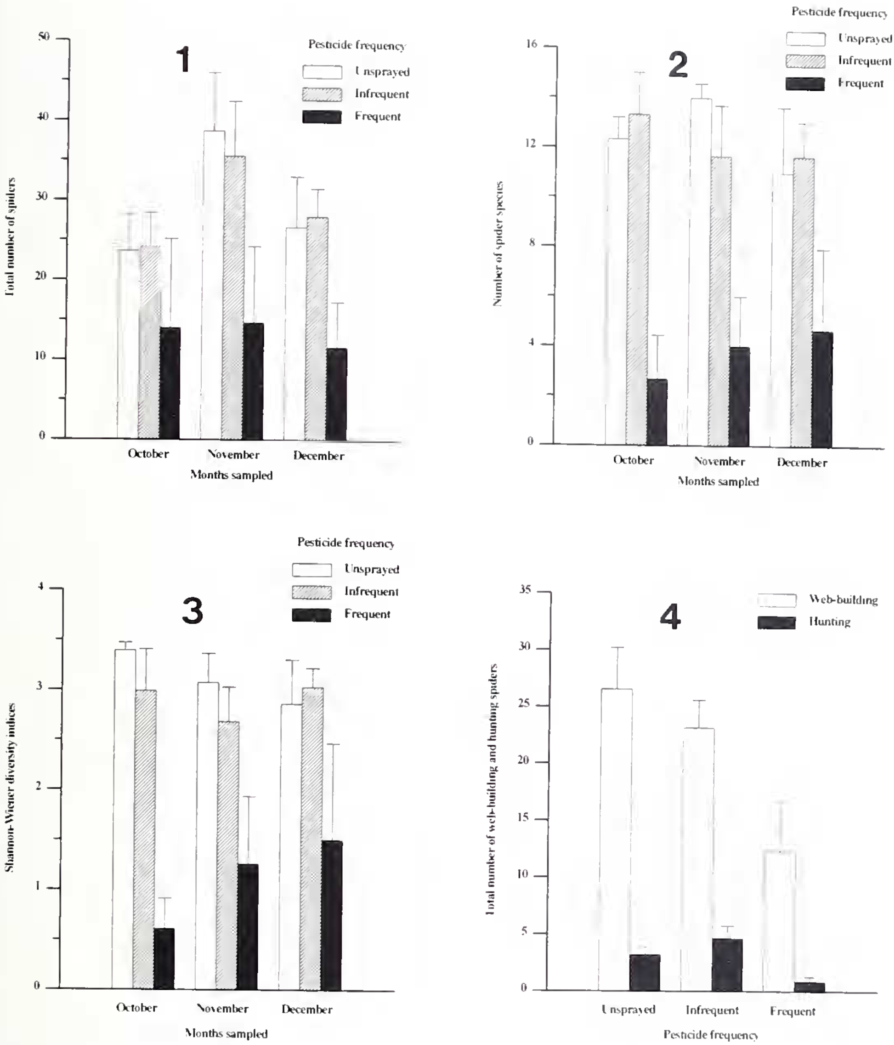
The infrequent use of pesticides did not appear to have the same disruptive effect as the more frequent use of pesticides. RIECHERT & LOCKLEY (1984) suggested that by limiting the amount and frequency of pesticides used in agroecosystems, spider

TABLE I

List of spider species with total number of individuals found in unsprayed and frequently sprayed mango orchards in Central Queensland during October, November and December, 1993.

Family	Species	Total no. of individuals unsprayed	Total no. of individuals frequently sprayed
F. Araneidae	* *Zealaranea* sp.	55	1
F. Araneidae	* *Argiope* sp.	17	16
F. Araneidae	* *Cyclosa* sp.	11	0
F. Araneidae	* *Cyrtophora exanthematica*	10	3
F. Araneidae	* *Cyrtophora hirta*	10	3
F. Araneidae	*Cyclosa* sp.	6	0
F. Araneidae	*Araneus praesignus*	5	2
F. Araneidae	*Poltys* sp.	3	4
F. Araneidae	*Nephila* sp.	1	3
F. Araneidae	*Cyclosa* sp.	3	0
F. Araneidae	*Gasteracanthus* sp.	3	0
F. Araneidae	*Nephila maculata*	3	0
F. Araneidae	unidentified immature	2	0
F. Araneidae	*Gasteracanthus taeniata*	1	0
F. Araneidae	unidentified immature	1	0
F. Clubionidae	*Cheiracanthium* sp.	3	0
F. Clubionidae	*Cheiracanthium* sp.	2	0
F. Desidae	*Badumna* sp.	19	66
F. Oxyopidae	*Oxyopes maculensis*	3	2
F. Oxyopidae	*Psuedohastus squamous*	1	1
F. Salticidae	*Cytaea* sp.	4	0
F. Salticidae	unidentified immature	3	0
F. Salticidae	*Cosmophasis bitaeniata*	2	0
F. Salticidae	unidentified immature	2	0
F. Salticidae	unidentified immature	1	0
F. Salticidae	unidentified immature	1	0
F. Salticidae	unidentified immature	1	0
F. Salticidae	unidentified immature	1	0
F. Salticidae	unidentified immature	1	0
F. Scytodidae	*Scytodes fusca*	0	3
F. Tetragnathidae	*Leucauge* sp.	2	0
F. Tetragnathidae	unidentified immature	1	0
F. Theridiidae	* unidentified immature	9	2
F. Theridiidae	* *Argyrodes antipodianus*	7	0
F. Theridiidae	*Archearania mundula*	5	1
F. Theridiidae	unidentified immature	4	0
F. Thomisidae	*Dianea* sp.	1	0
F. Thomisidae	*Xysticas* sp.	1	0
F. Thomisidae	unidentified immature	1	0
unidentified	immature	4	0
unidentified	immature	3	0
unidentified	immature	2	0
unidentified	immature	1	0

* large decreases in spider abundance when comparing unsprayed with frequently sprayed orchards.



FIGS 1–4

Fig. 1: The mean and standard errors of spider abundance in frequent, infrequently and frequently sprayed (n = 3, n = 6 & n = 3, respectively) mango orchards during spring/summer 1993 in Central Queensland. Fig. 2: The mean and standard errors of number of species in frequent, infrequently and frequently sprayed orchard (n = 3, n = 6 & n = 3, respectively) mango orchards during spring/summer 1993 in Central Queensland. Fig. 3: The mean and standard errors of Shannon-wiener diversity indices for frequently, infrequently and un-sprayed (n = 3, n = 6 & n = 3, respectively) mango orchards during spring/summer 1993 in Central Queensland. Fig. 4: The mean and standard errors of abundance of web-building and hunting spiders in frequent, infrequent and un-sprayed (n = 3, n = 6 & n = 3, respectively) mango orchards during spring/summer 1993 in Central Queensland.

numbers and diversity may be conserved. The results from this study suggest that infrequent use may indeed maintain spider numbers and diversity. However, the relative abundance of spider species (community structure) appears to have been disrupted in orchards with infrequent as well as frequent pesticide use. This suggests that some spider species are more susceptible to pesticides than others. When the abundance of each species was compared for unsprayed and frequently sprayed orchards a similar result was observed. Out of the 44 species collected, 38 species decreased in abundance suggesting susceptibility to the pesticides. The largest decreases were found for the (species marked), whereas *Badumna* sp. was the only spider which showed a significant increase in numbers (Table 1). If those spiders which are most susceptible to pesticides are also the most effective predators of pest species then even the infrequent use of pesticides will diminish biocontrol. The results of this study suggest that the relationship between effective predation of pest species and susceptibility to pesticides needs to be investigated for such naturally occurring biocontrollers.

Both web-building and hunting spiders appeared to be susceptible to the frequent use of pesticides. This result conflicts with the generally accepted conception, that web-building spiders are more susceptible to pesticides because they are directly exposed to the fumigation process as webs tend to collect agrochemical sprays (Samu *et al.* 1992). Hunting spiders are more likely to avoid the pesticides as webs are not used and due to their behaviour of hiding.

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